SST™

Detailed Forensic Report Certification

I, Scott T Weiser, declare:

That I am Customer Support Engineer at SST, Inc. I have personal knowledge of the following matter, and, if called as a witness, could and would testify thereto. I have prepared the report and any attachments, identified below, which is attached hereto.

I declare under penalty of perjury under the laws of the State of California that the report is true and correct.

Report:

City :	**San Francisco, CA**
Zone :	**Mission**
Reference Date :	**07 APR 2016**
Customer's Ref. #:	**CAD# 1237**
Report Date :	**18 APR 2016**
MD5 Hash (PDF):	BEACC4CB21CAE41035090B162F215D4E
SVN Revision (PDF):	**63873**

Executed this 19 of APRIL, 2016, at NEWARK, CA.

Scott T Weiser

sweiser@shotspotter.com

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Detailed Forensic Report

City :	San Francisco, CA
Zone :	Mission
Reference Date :	07 APR 2016
Customer's Ref. #:	CAD# 1237
Report Date :	18 APR 2016

Shooting Description

At 10:04:04 (10:04:04 AM) hours on April 7, 2016 ShotSpotter detected a Multiple Gunshot incident in San Francisco, CA. ShotSpotter recorded the incident as Flex ID #30436 and located it at 3251 18th St.

Incident Time Analyzed

The spool data was reviewed for 10:04:04 hours on April 7, 2016.

Position With Respect to the Coverage Area

Figure 1 – ShotSpotter Coverage Area displays the ShotSpotter coverage in San Francisco, CA at the time of the incident. The red dot indicates the location of the shooting incident, the red dashed line denotes the boundaries of the ShotSpotter coverage area, and the triangle symbols represent the sensors that participated in detecting the incident.

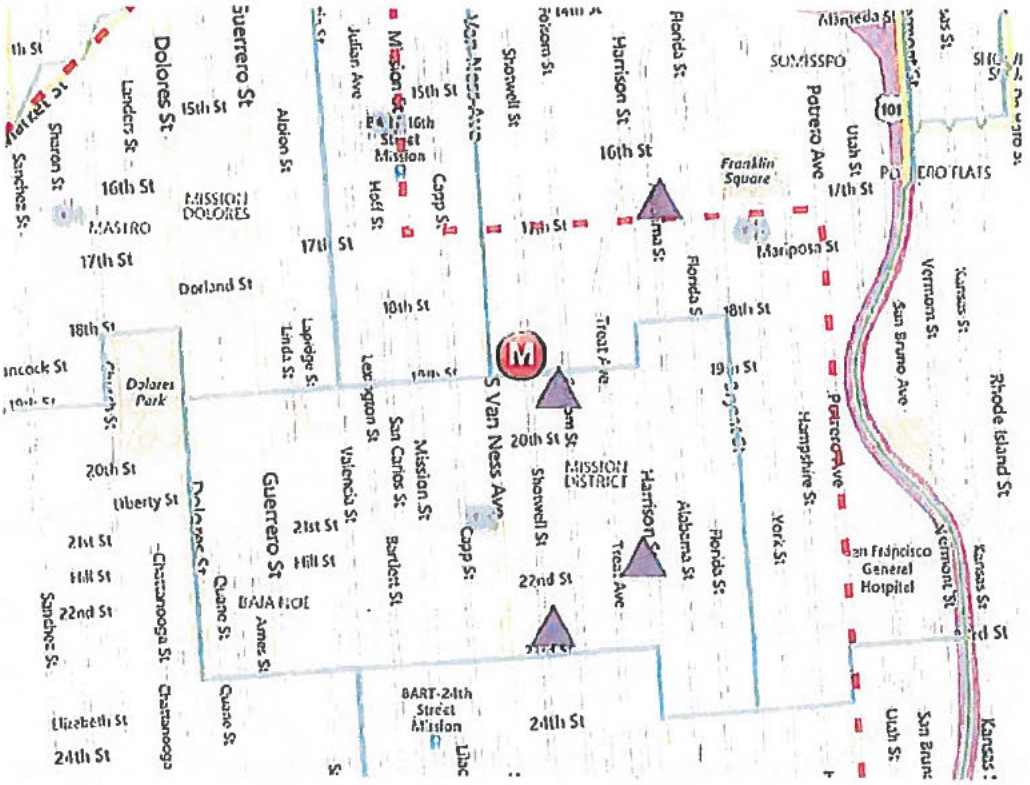

Figure 1 - ShotSpotter Coverage Area San Francisco, CA

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Auto-detected by ShotSpotter? Yes

About ShotSpotter

ShotSpotter was installed in San Francisco, CA in 2008. ShotSpotter has three primary components: acoustic sensors, a Location Server application, and the ShotSpotter Flex user interface. The ShotSpotter Location Server is operated by SST, Inc. and runs on a virtual server hosted at a remote facility, the ShotSpotter Flex user interface resides on a PC at the customers dispatch facility, and the acoustic sensors are deployed in geographic areas that are designated by the customer.

Each sensor is triggered by impulsive sounds in its environment. The acoustic measurements of these impulsive sounds and the exact time that they were detected are transmitted to the Location Server as possible gunshot sounds. The Location Server analyses the data received and determines if the impulsive sound can be located and classified as gunfire. If the impulsive sound can be located and classified as gunfire it reports the incident to the SST Service Operations Center where a human operator reviews the incident for classification accuracy. The reviewed gunfire incident is then published to the customers user interface. The user interface, referred to as the Flex Alert Console, provides an actionable view of the incident with an emphasis on the time and location that the shooting occurred. Gunfire incidents are typically detected, located, reviewed, and published to the customer in less than 60 seconds.

ShotSpotter detects and properly geo-locates (provides latitude and longitude) 80% of detectable outdoor incidents within the coverage area, accurate to within a circle whose radius is 25 meters. SST, Inc. does not guarantee 100% detection because real world, urban environments may contain intervening buildings, topography, foliage, periods of increased traffic or construction noise, and other urban acoustic noises that may either prevent the sound of a gunshot from being detected by the sensors(s), or may change or modify the audio characteristics of the sound of a gunshot so that it no longer matches the sensor(s) detection parameters.

Other factors, such as obstructed or attenuated muzzle blast, weapon discharge in an enclosed space, or if the weapon discharged is of .22 or smaller caliber, may also prevent the sensor(s) from not detecting all, or some shots fired.

Analysis

Figure 2 – Incident review At 10:04:04 on April 7, 2016, ShotSpotter detected and located a Multiple Gunshot incident in San Francisco, CA. Below is a table which shows the timeline of the incident being updated.

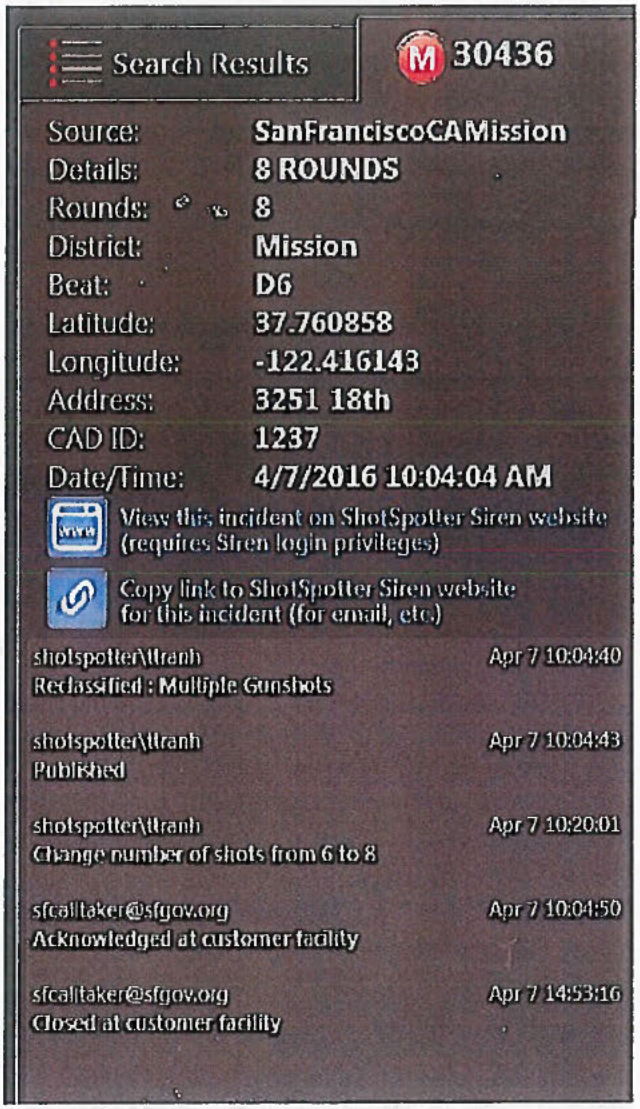

Figure 2 – Flex ID #30436 Incident review timeline

Figure 3 – Address Location displays the locations calculated by ShotSpotter. The address of 3251 18th St was read from either a database of parcel information provided by the city or county and uploaded into ShotSpotter or from the map provider. The red dot indicates the location of the shooting incident as calculated by ShotSpotter in real-time and reported to the ShotSpotter operator.

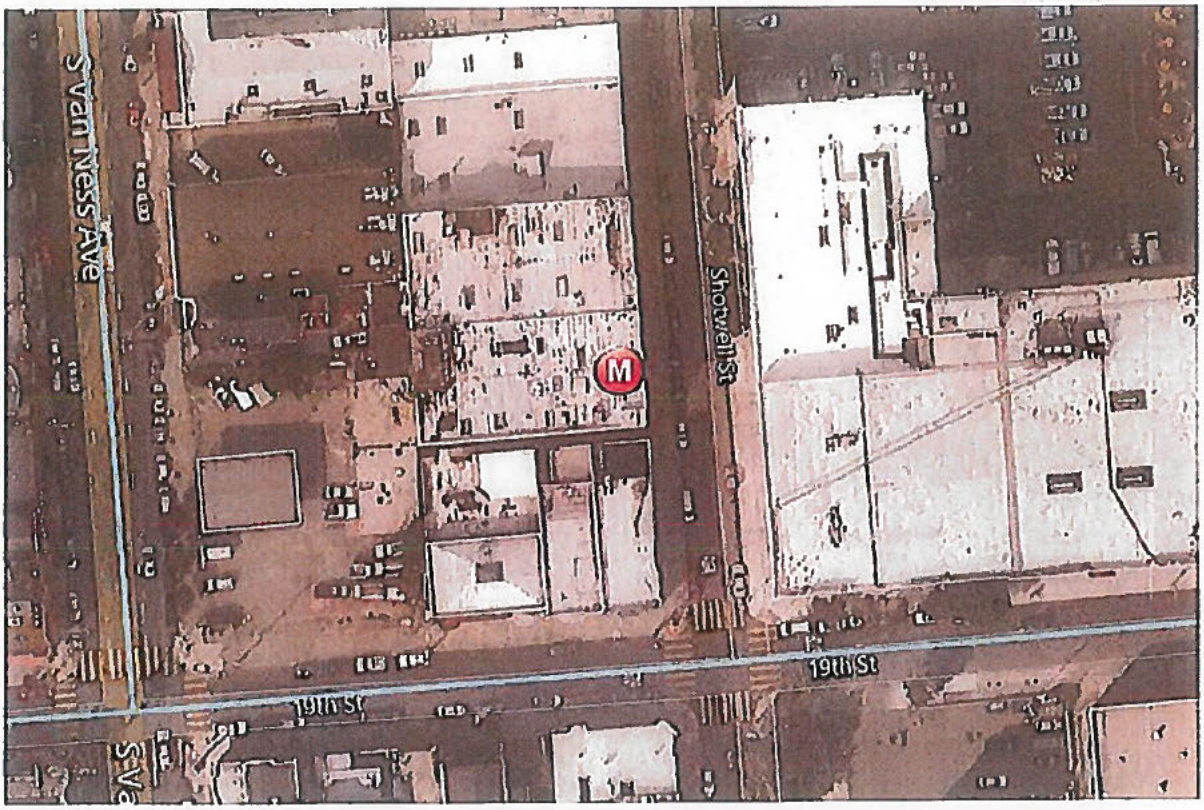

Figure 3 – Flex ID #30436 Flex Location

Table 1 – Timeline of Discharge of Shots: The following table shows the time of discharge for each of the rounds which comprise this shooting event. The times listed below are the time the system calculated the trigger was pulled based on the environmental conditions at the time of the event. These times precede the time at which the system notified the ShotSpotter Operator listed because of small radio, computational, and network delays. All times are obtained from system and sensor clocks that are synchronized to GPS time, which is in turn synchronized with the atomic clock at the National Institute of Standards and Technology in Boulder, CO.

During analysis of the spool audio, three additional pulses were found on sensor 17 prior to those contained in the automatic alert. These three pulses, along with the first pulse in the automatic alert, were only recorded on sensor 17.

Note that the system did not capture sufficient data to calculate the trigger time for shots 1-4. The times in red below represent the time the pulse arrived at sensor 17 for each of these four shots. The listed sensor arrival times for shots 1-4 are later than the actual trigger times based on the speed of sound and the environmental conditions at the time of the event.

Shots 5-11 represent the trigger times calculated by the ShotSpotter system as explained above.

Shot	Time
1	10:03:58.772
2	10:04:00.960
3	10:04:03.146
4	10:04:04.276
5	10:04:04.283
6	10:04:04.675
7	10:04:05.040
8	10:04:05.430
9	10:04:05.674
10	10:04:06.012
11	10:04:06.446

Table 1 – Shot timeline, Flex ID #30436

Figure 4 – Individual Shots Fired The following image plots the location of each round fired in Google Earth. This image is created by post-processing the archived data. Post-processing is a "manual" re-evaluation of the archived data through software tools that duplicate the real-time location algorithms that are a resident part of the ShotSpotter Location Server. Post-processing can be selectively performed on subsets of the raw data so that noises from different sources can be isolated for analysis. The locations calculated in post-processing are not identical to, but are typically within normal limits of what the ShotSpotter calculated in real-time.

In the image below the red dots indicate the location of each of the rounds fired. The yellow circle indicates a 25m margin of error radius for gunshot incidents that occur within the boundaries of the coverage area depicted on page 1 and is present in the image for reference only.

During analysis, it was determined that the automatically calculated location was incorrect by approximately 20m to the West due to ShotSpotter mismatching gunfire and echo pulses.

After analysis, the location was corrected to 3235 18th St. (37.760835, -122.415958).

Due to insufficient pulse data for shots 1-4, location analysis was only performed on shots 5-11.

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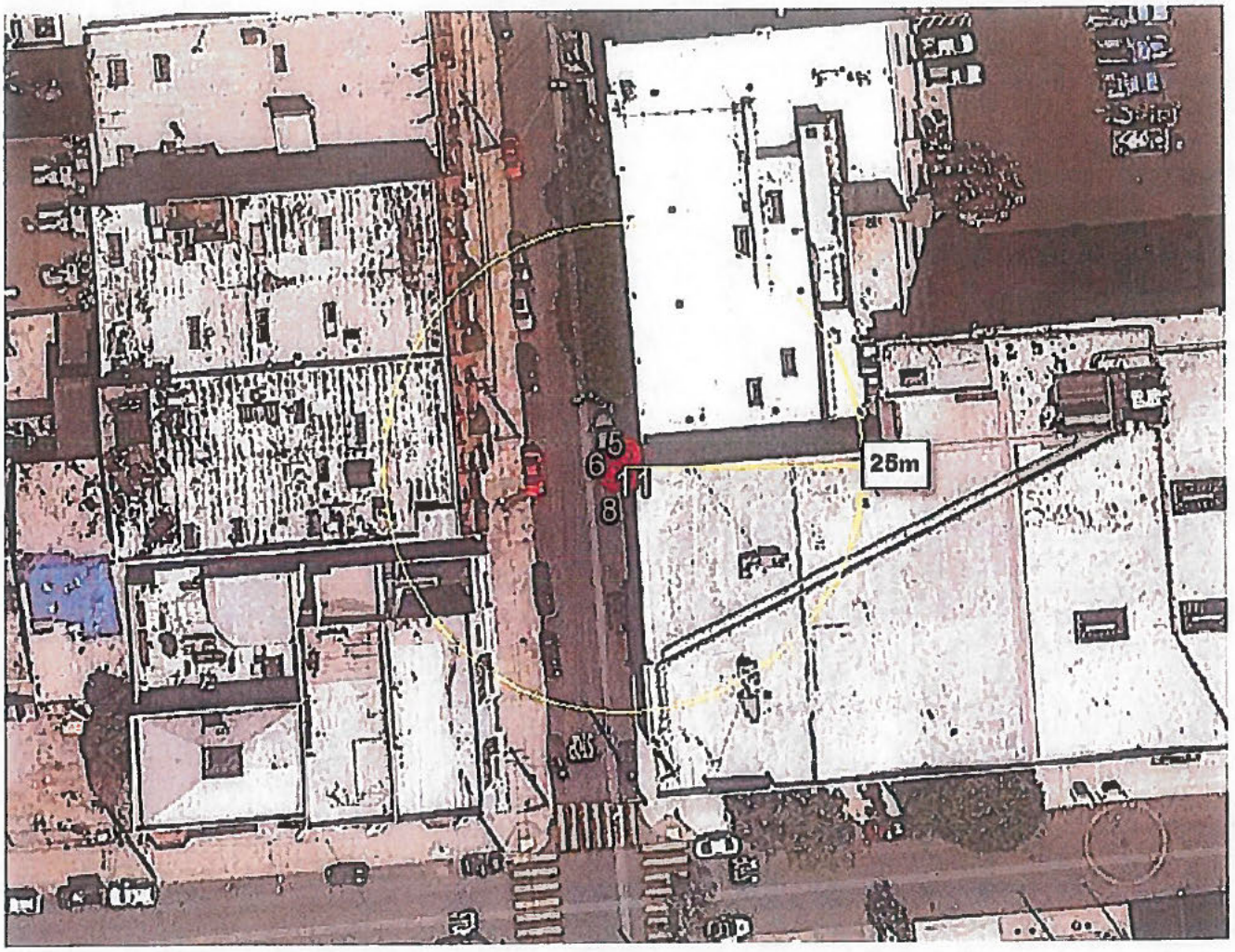

Figure 4 – Individual Shot Locations, Flex ID #30436

Multilateration:

The firing of a gun or an explosive device creates a loud, impulsive sound that can, under optimum environmental conditions, be detected above urban background noise up to two miles away from the firing incident location. The operation of ShotSpotter is understandably subject to the laws of physics and acoustic propagation.

The source of a pulse (a sound that goes bang, boom, or pop) is located using a mathematical process called multilateration. Multilateration requires a minimum of three sensors that surround the source to accurately report the time that a pulse is detected. Each participating sensor will detect that pulse at slightly different times. The Location Server calculates the time differences between pairs of sensors to generate a curve called a hyperbola. All of the resulting hyperbolae are then plotted onto a map. The spot where the hyperbolae intersect is where ShotSpotter locates the shot. When more than three sensors participate in the detection, Location Server performs automatic calculations to find a solution that minimizes the error to the greatest extent possible.

Figure 5 – Multilateration plot Flex ID #30436 was detected by four sensors.

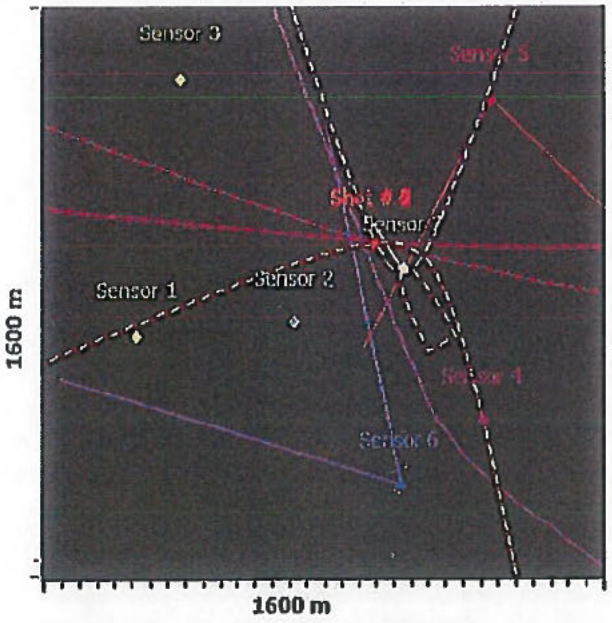

Figure 5 - Multilateration, Flex ID #30436

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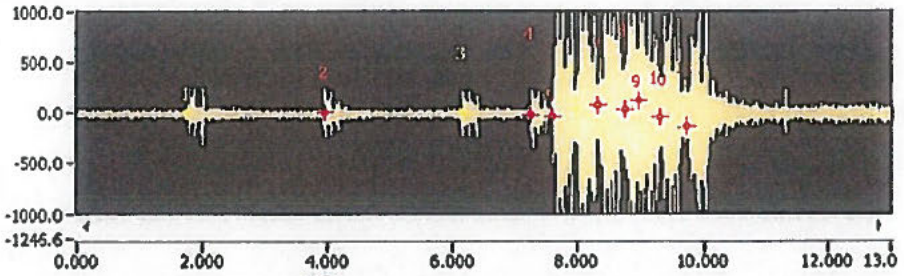
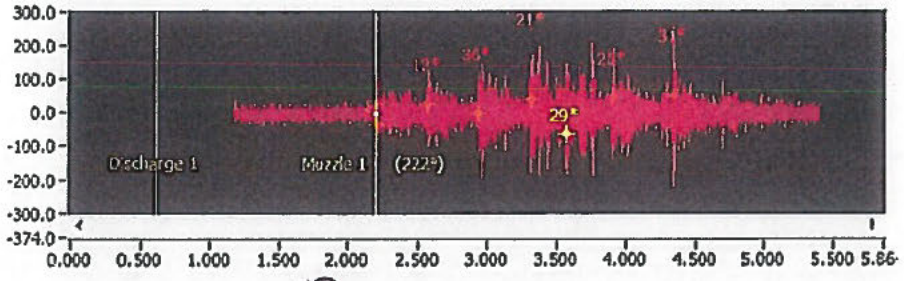
Site-specific Acoustics

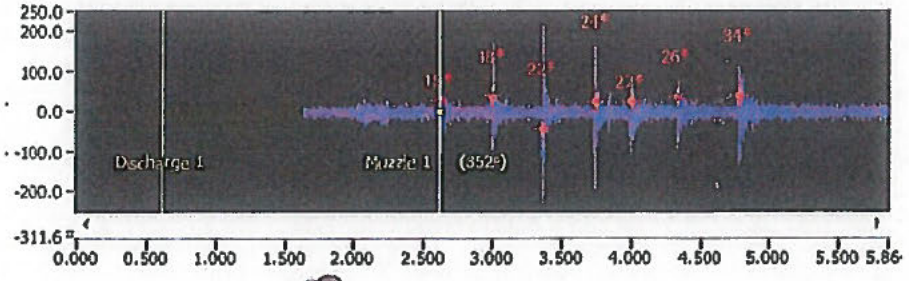
The sound of these shooting events can be heard on many sensors. Below are pictorial representations of the audio clips and a link to the corresponding .wav file for three sensors close to the incident. The depicted audio waveforms and audio clips represent 13.0 seconds of audio that was manually downloaded from sensor 17, and 4.22 seconds of audio that was automatically downloaded from sensors 13 and 14. (Double-click on the speaker icons to play the audio from each sensor.)



Sensor 17 (112m)



Sensor 13 (514m)



Sensor 14 (686m)

Conclusion

At 10:04:04 (10:04:04 AM) hours on April 7, 2016 ShotSpotter detected a Multiple Gunshot incident in San Francisco, CA. ShotSpotter recorded the incident as Flex ID #30436 and located it at 3251 18th St.

After analysis, the location was corrected to 3235 18th St. (37.760835, -122.415958).

After review, the locations and times of seven rounds fired were calculated. Additionally, the sensor arrival times of four rounds fired prior to the seven were noted.

Acoustical data analysis of a gunfire incident is complex and not comprehensive. The conclusions above should be corroborated with other evidentiary sources such as recovered shell casings, and witness statements.

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Certification and Acknowledgement

Certification

I, Scott T Weiser, declare that I am a, Customer Support Engineer at SST Inc. I have personal knowledge of the matter referred to in this report, and, if called as a witness, could and would testify thereto. I declare that the above is true and correct.

Executed this 19 of April, 2016,

at Newark, CA.

Scott T Weiser

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A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document

California All-Purpose Certificate of Acknowledgement

State of California)
County of Alameda)

On 19 April 2016
before me Michele Puente,
Notary Public personally appeared Scott T Weiser who provided to me on the basis of satisfactory evidence to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument the person, or the entity upon behalf of which the person acted, executed the instrument.

I certify under the laws of the State of California that the foregoing paragraph is true and correct.

Witness my hand and official seal.

Signature
Notary Public

MICHELE PUENTE
Commission # 2133311
Notary Public - California
Santa Clara County
My Comm. Expires Dec 4, 2019